

ICESat-2 in the mid-latitudes and some lessons learned

Tom Neumann, Project Scientist, on behalf of the ICESat-2 Project and Science Team



Ben Smith, University of Washington

Greenland ice sheet elevation, 2019



Mission Overview



Successor to ICESat (2003-2009)

Designated as a top priority in the 2007 Earth Science Decadal Survey

ATLAS: Advanced Topographic Laser Altimeter System

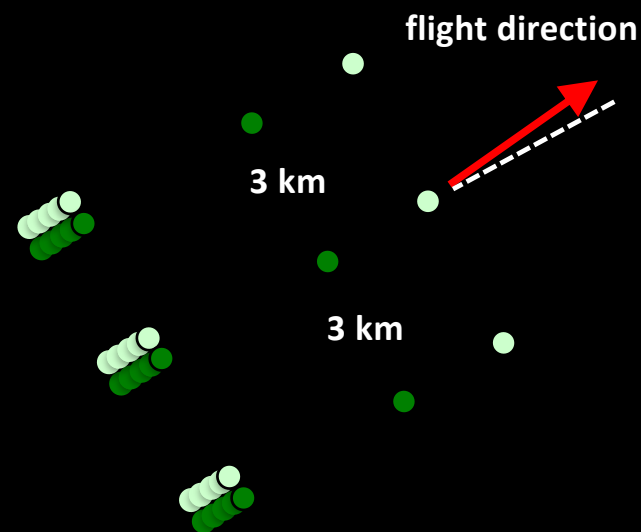
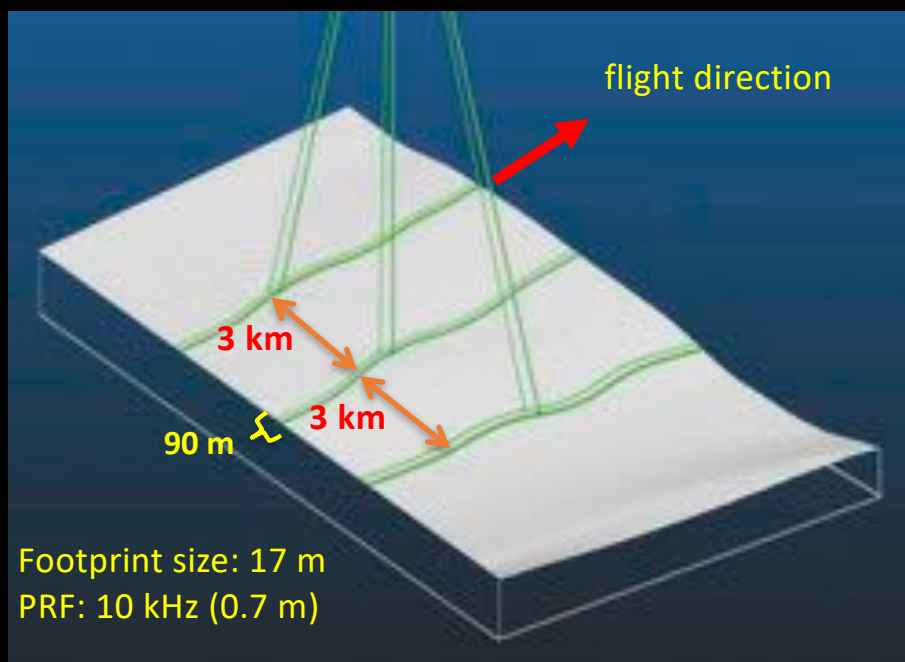
Launched successfully 15 September 2018



Measurement Concept



Single laser pulse at 532nm, split into 6 beams. Single-photon sensitive detection.



3 km spacing between pairs provides spatial coverage

90 m pair spacing for *slope determination*

high-energy beams for better performance over low-reflectivity targets.

Current Status

367 days on orbit since launch

ATLAS: transmitting laser light since 1 October 2018

292 billion laser pulses (compared with 2 billion from ICESat)

6 beams, arranged in pairs

17 m footprint diameter

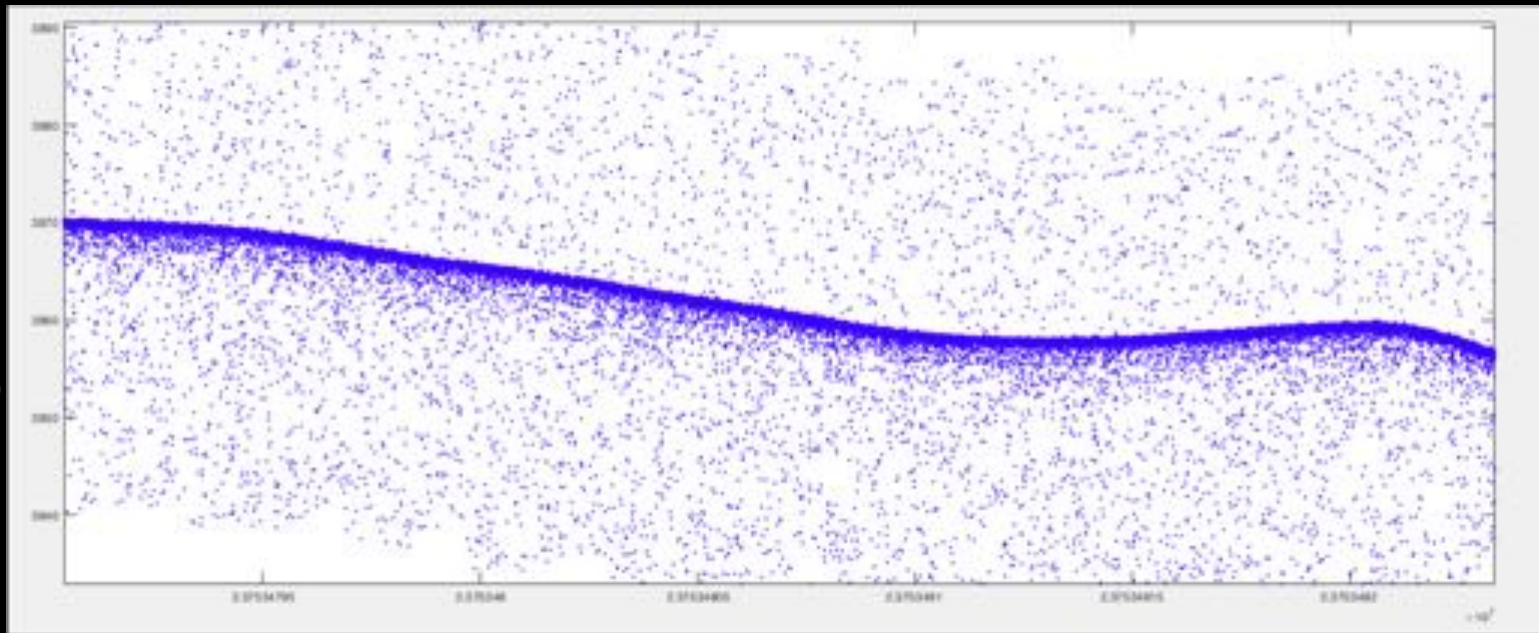
0.7 m along-track spacing

Performance metrics remain nominal, and within requirements

ATL03: Geolocated Photons



Height WRT WGS-84



Along track time or distance

3 October 2018!

ATL03: Geolocated Photons



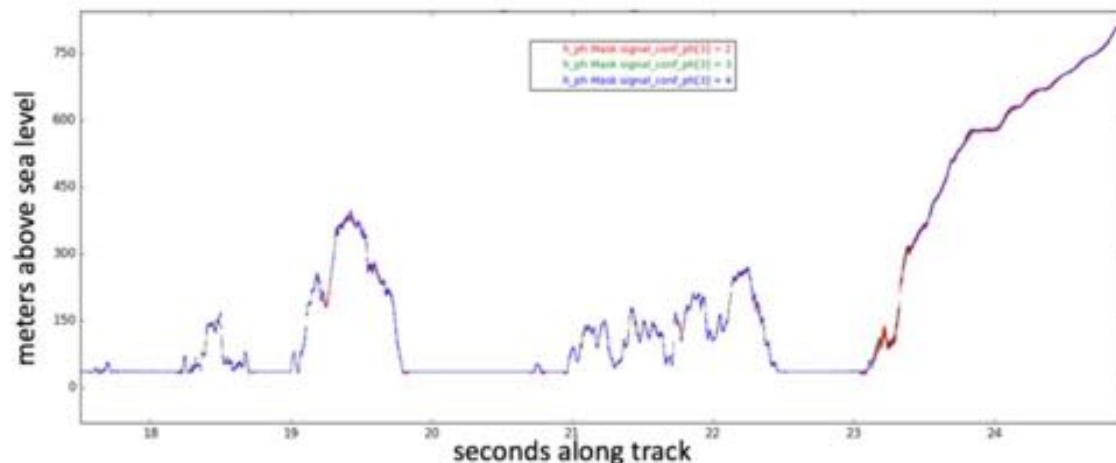
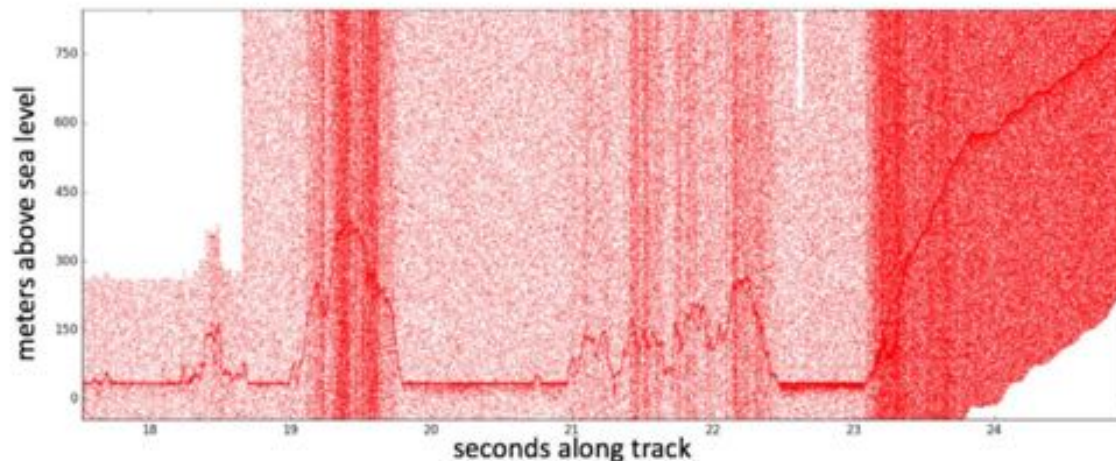
Classify Photons

Reduce data volume
higher-level products
have to deal with

Histogram-based
approach

Parameters are surface
specific

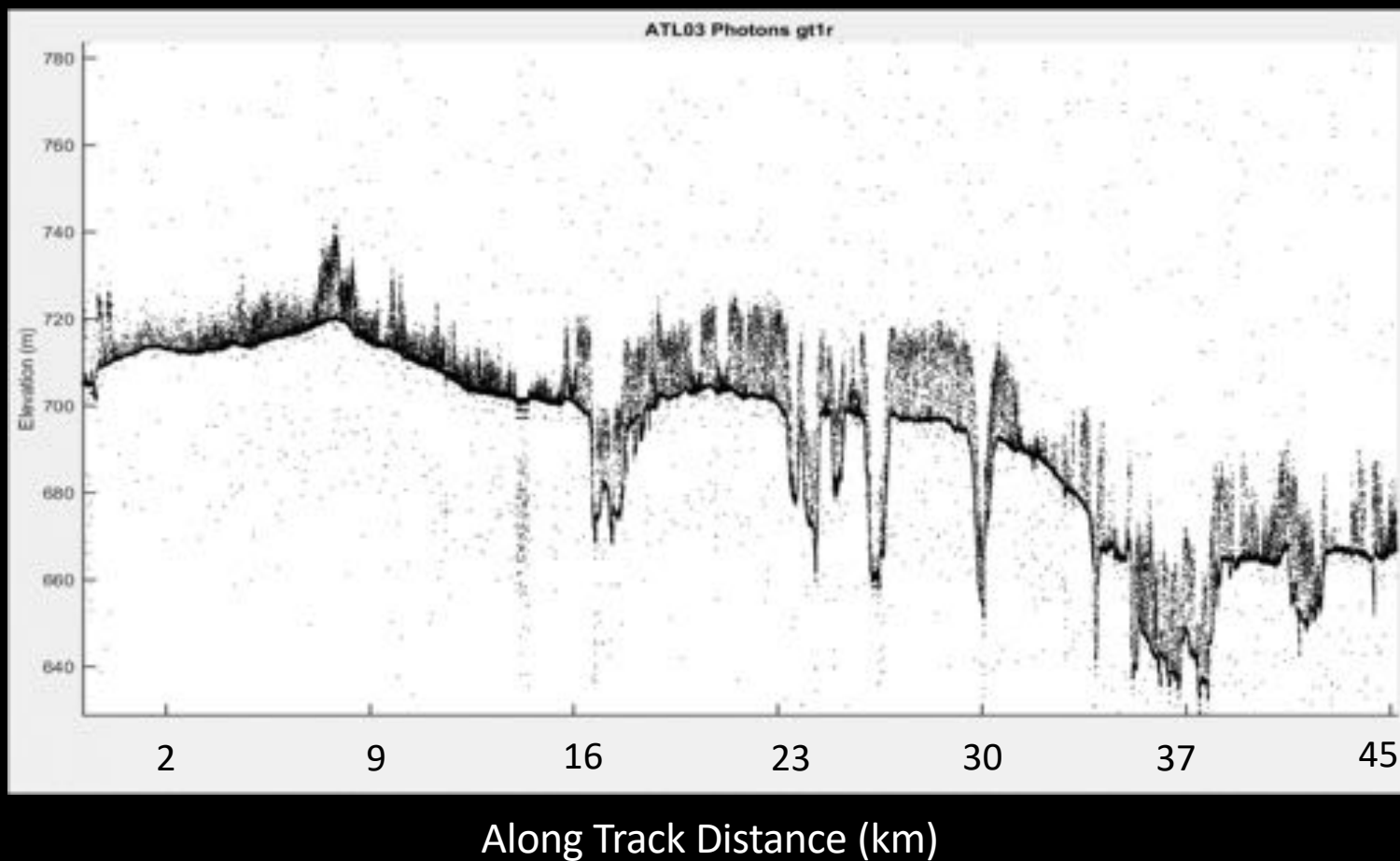
Likely signal photons
w/ high, medium or
low confidence



ATL03: Geolocated Photons



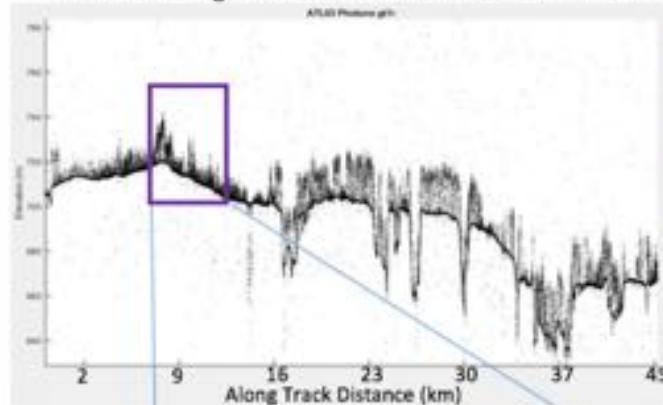
Eastern
British
Columbia



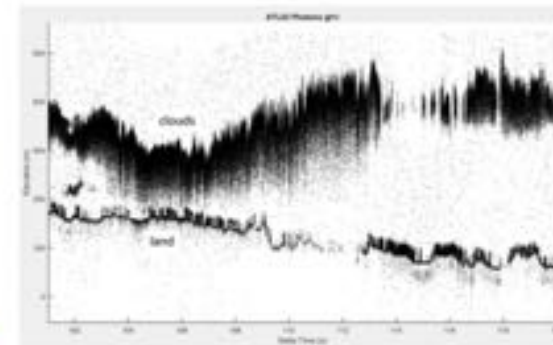
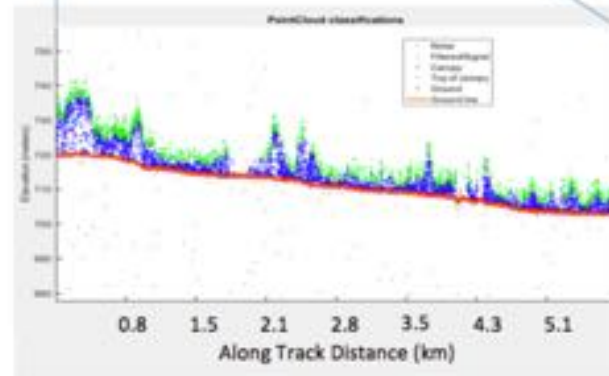
ATL08: Vegetation and Canopy

Uses 100m segments to further reject noise, and classify photons

Profile through Boreal Forest in Eastern British Columbia



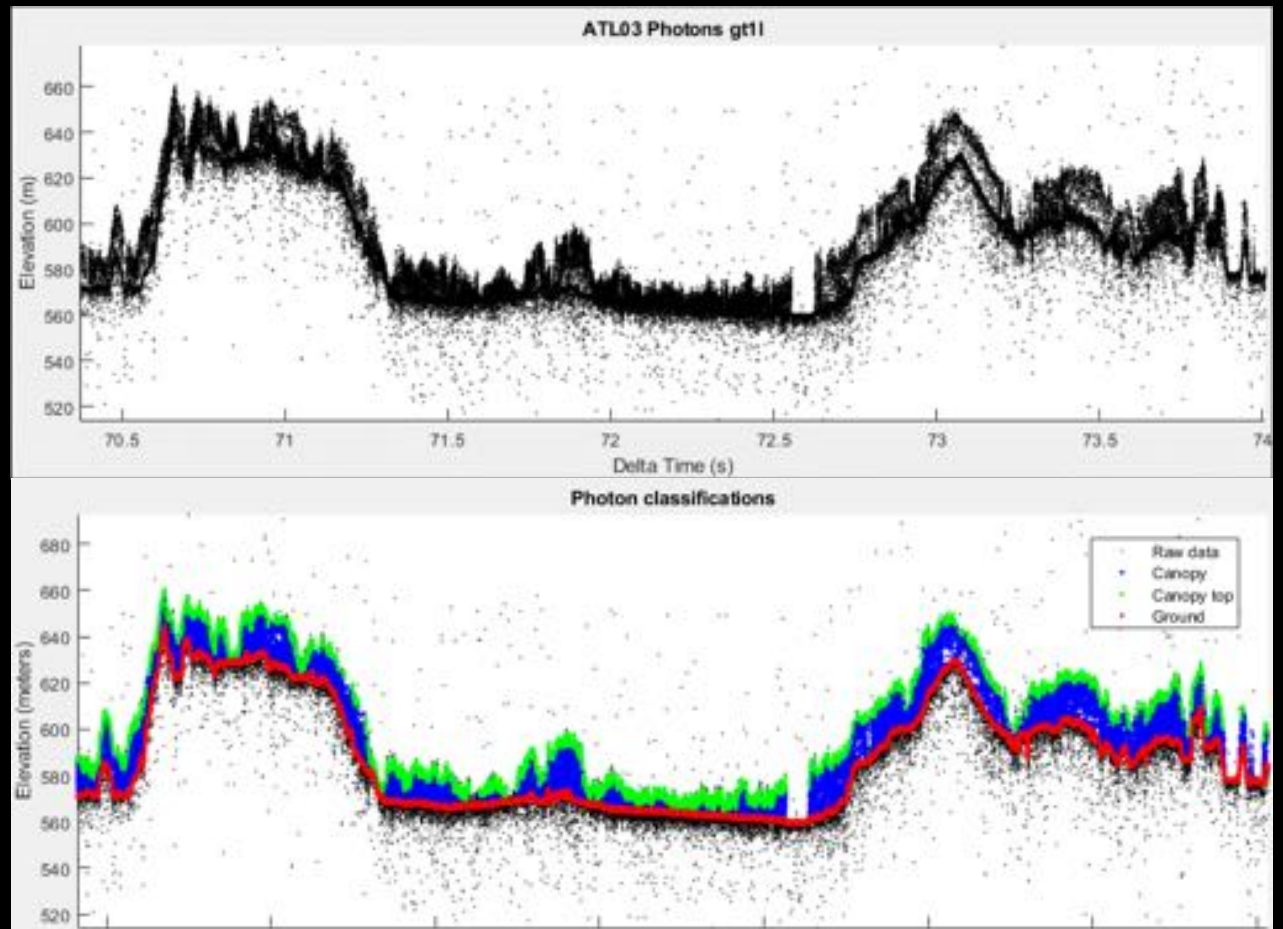
Example of ATL08 Photon Classification for Tropical and Boreal Forest. Data from ICESat-2 will aim to provide global estimates of canopy heights and/or improve biomass estimates globally.



Much like low beam headlights on a car penetrating through fog, the lower energy and photon counting capability of ICESat-2 can penetrate clouds of some TBD optical depth revealing the ground surface below.

Amy Neuenschwander, U Texas

ATL08: Vegetation and Canopy



ICESat-2 Data are Publicly Available



National Snow and Ice Data Center (NSIDC DAAC)

Data Products:

Geolocated Photons

Land Ice Elevation

Sea Ice Elevation and Freeboard

Land Elevation

Atmospheric Backscatter

Ocean Surface Height

Inland Water Elevation

1342 data users to date

777,410 files served from May 28 – Sep 8

NASA Distributed Active Archive Center (DAAC) at NSIDC

ICESat-2 Data

Ice, Cloud, and Land Elevation Satellite-2 Data

Overview

ICESat-2 Data Sets

Product Descriptions

Level-1

Level-2

Level-3A

Level-3B

Tools

Knowledge Base

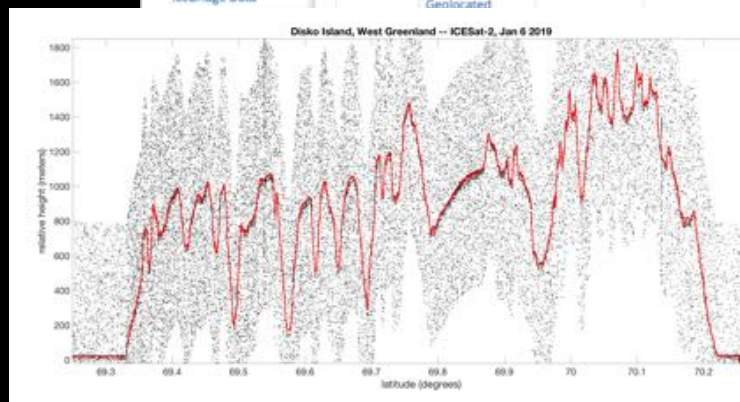
ICESat/GLAS Data

IceBridge Data

ICESat-2 Data Sets at NSIDC

The following table lists the ICESat-2 data sets that are currently available at the NASA NSIDC DAAC.

ID	Title	Spatial Coverage	Temporal Coverage	Spatial Resolution	Temporal Resolution	Parameter(s)
ATL02	ATLAS/ICESat-2 L1B Converted Telemetry Data, Version 1	GLOBAL	2018/10/13 to present	Not applicable	Not applicable	Engineering Telemetry Ancillary Data
ATL03	ATLAS/ICESat-2 L2A Global Geolocated	GLOBAL	2018/10/13 to present	70 cm	91 day	TERRAIN ELEVATION
				80 m	91 day	Lidar Backscatter



ATL03 data over rugged topography in Greenland

Orbit and Coverage

500 km altitude

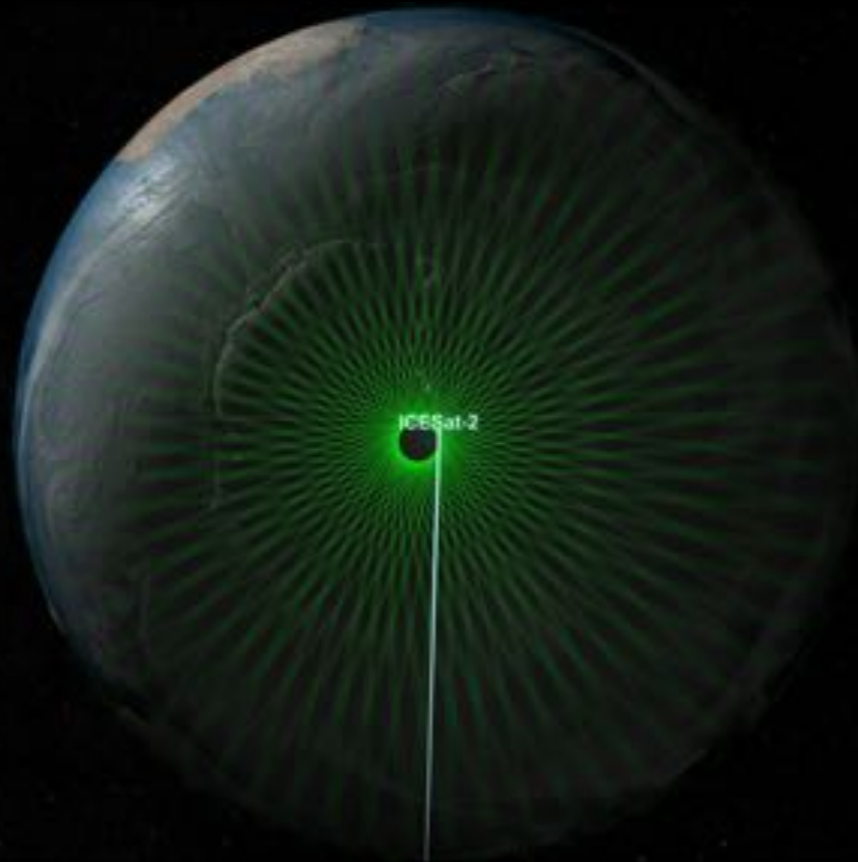
88S to 88N

15 revs/day

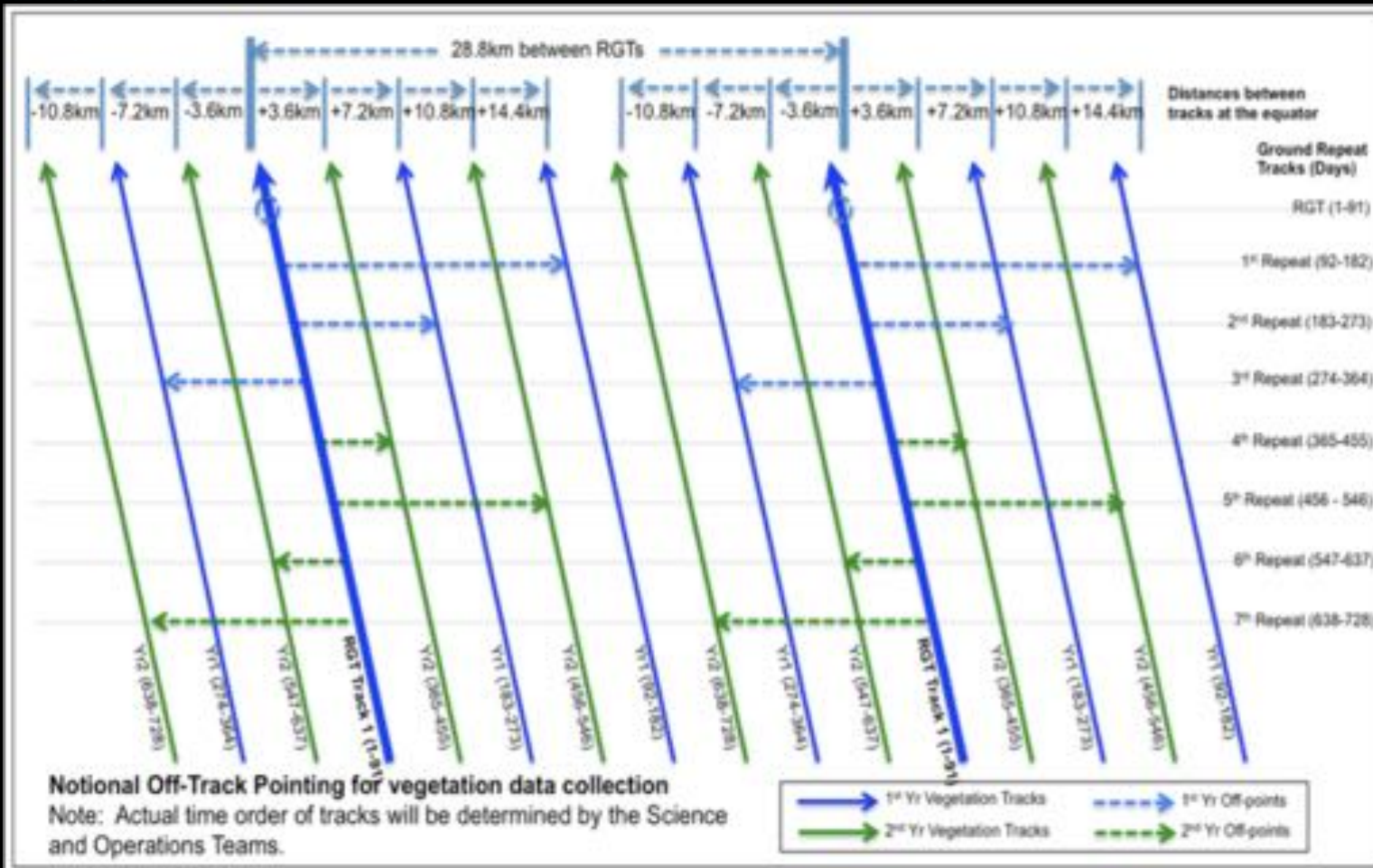
1387 tracks

91-day revisit

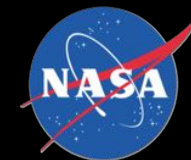
**Ground tracks at
icesat-2.gsfc.nasa.gov**



Off Pointing in Mid-Latitudes



Grand Mesa, CO




via NSIDC spatial search tool

Overview Download Data Editing Theme Data User Guide Technical References Support

Filter by date: From 10/13/2018 To 09/14/2019

Filter spatially by drawing a polygon

Show Instructions



23 Files selected (1.04 GB)

File Name	Size (MB)	Start Time	End Time
ATL03_20190417T0415A_00900002_001_01.H5	5199.9	2019-04-17 13:47:54	2019-04-17 13:56:34
ATL03_20190418T0334A_00700006_001_01.H5	483.8	2019-04-18 02:03:44	2019-04-18 02:12:14
ATL03_20190419T0307A_00400002_001_01.H5	2895.7	2019-04-19 01:58:13	2019-04-19 02:04:46
ATL03_20190419T1305A_00100006_001_01.H5	827.2	2019-04-19 02:13:05	2019-04-19 02:20:36
ATL03_20190515T0015A_11760002_001_02.H5	4434.8	2019-05-15 15:20:19	2019-05-15 15:28:46
ATL03_20190514T0334A_11560006_001_02.H5	1091.9	2019-05-14 03:36:46	2019-05-14 03:44:36
ATL03_20190510T0344A_10900006_001_02.H5	7293.8	2019-05-10 03:44:36	2019-05-10 03:52:36
ATL03_20190514T0441A_07370002_001_01.H5	5747.4	2019-05-14 16:44:19	2019-05-14 16:52:44
ATL03_20190513T0300A_07140006_001_01.H5	968.8	2019-05-13 03:00:03	2019-05-13 03:08:03
ATL03_20190510T0324A_06760002_001_01.H5	4548.5	2019-05-10 16:52:34	2019-05-10 17:01:04
ATL03_20190509T0302A_06500006_001_01.H5	1343.0	2019-05-09 03:08:03	2019-05-09 03:16:03
ATL03_20190518T0337A_00900002_001_01.H5	4493.0	2019-05-18 18:07:50	2019-05-18 18:16:20
ATL03_20190518T0337A_00700006_001_01.H5	1268.7	2019-05-18 06:23:43	2019-05-18

Download

Grand Mesa, CO



Reference Ground Tracks
repeat every 91 days

Currently in Cycle 4 (off pointing by ~7 km)

5 RGTs intersect Grand Mesa every 91 days:

211
714
737
1156
1179

Each RGT has 3 strong and 3 weak beams
associated with it.

RGT locations (green lines) account for
off-pointing plan.



Grand Mesa, CO



Reference Ground Tracks
repeat every 91 days

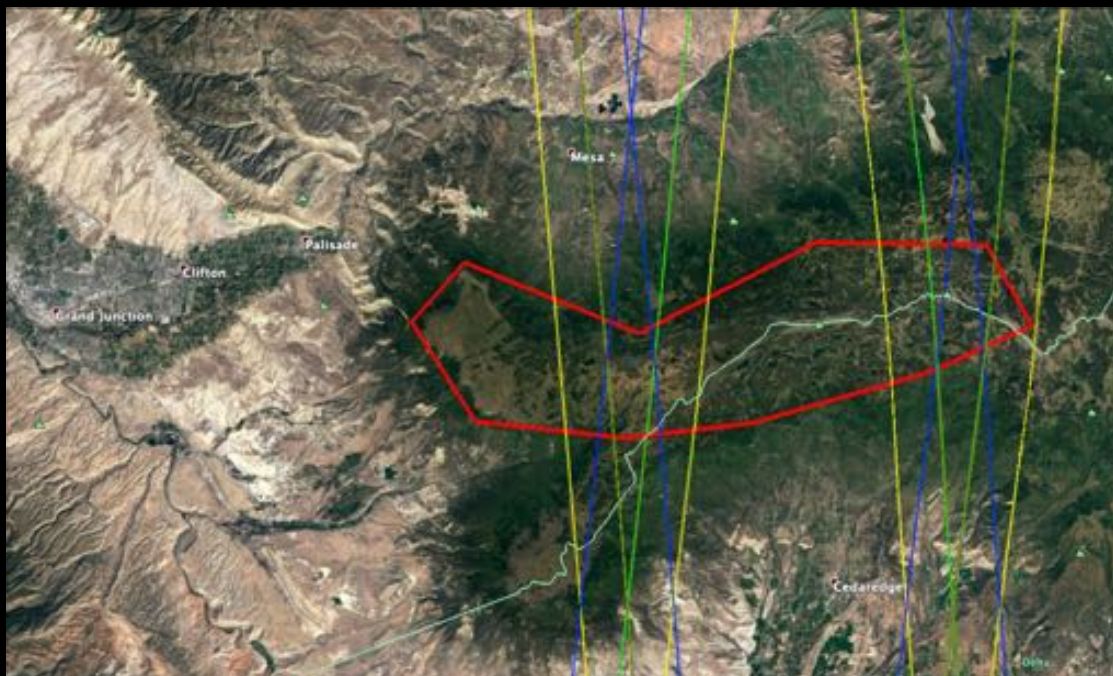
Cycle 6 begins late December

5 RGTs intersect Grand Mesa every 91 days:

211
714
737
1156
1179

Some are ascending passes, some descending

Yellow is right pair
Green is center pair
Blue is left pair



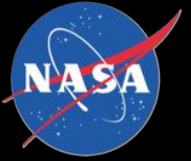
Major ICESat-2 Trades



What were some of the major trades in the development of ICESat-2?
What did we learn?



Major ICESat-2 Trades



The Lidar Equation relationship between transmitted power, received power, and range to target (among many other things)

- laser energy per pulse
- telescope (FOV) size
- orbit altitude
- surface reflectivity
- receiver sensitivity / received energy per pulse
- total optical power
- atmospheric scattering / attenuation
- divergence
- laser pulse repetition frequency

A robust link model of the instrument is critical for evaluating these trades

Major ICESat-2 Trades



Orbit: feeds into link model, determines data coverage at any latitude and revisit interval.

- altitude
- inclination
- physics

Compromise between coverage at high latitude, coverage at sea ice edges, and coverage at equator.

92° inclination, 500 km altitude

→ 1387 revs every 91 days

→ coverage to 88N and 88S

ICESat-2 Measures



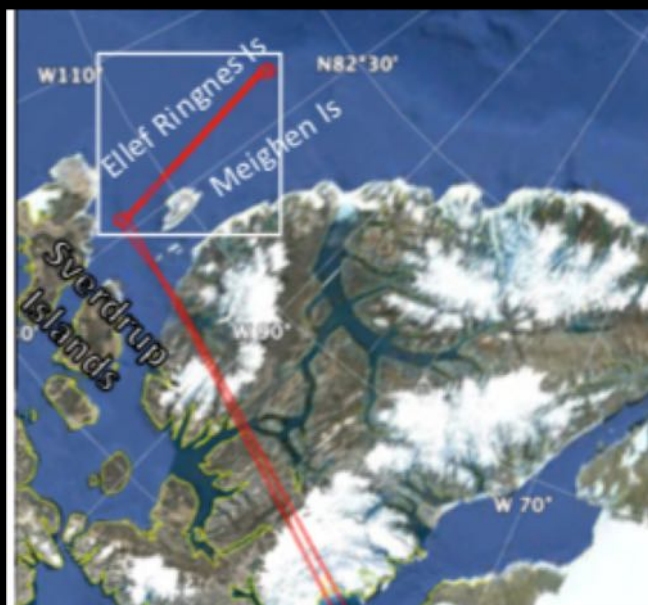
ICESat-2 well on it's way to meeting science requirements:
ice sheet elevation, sea ice freeboard, vegetation canopy height

Initial science papers in review

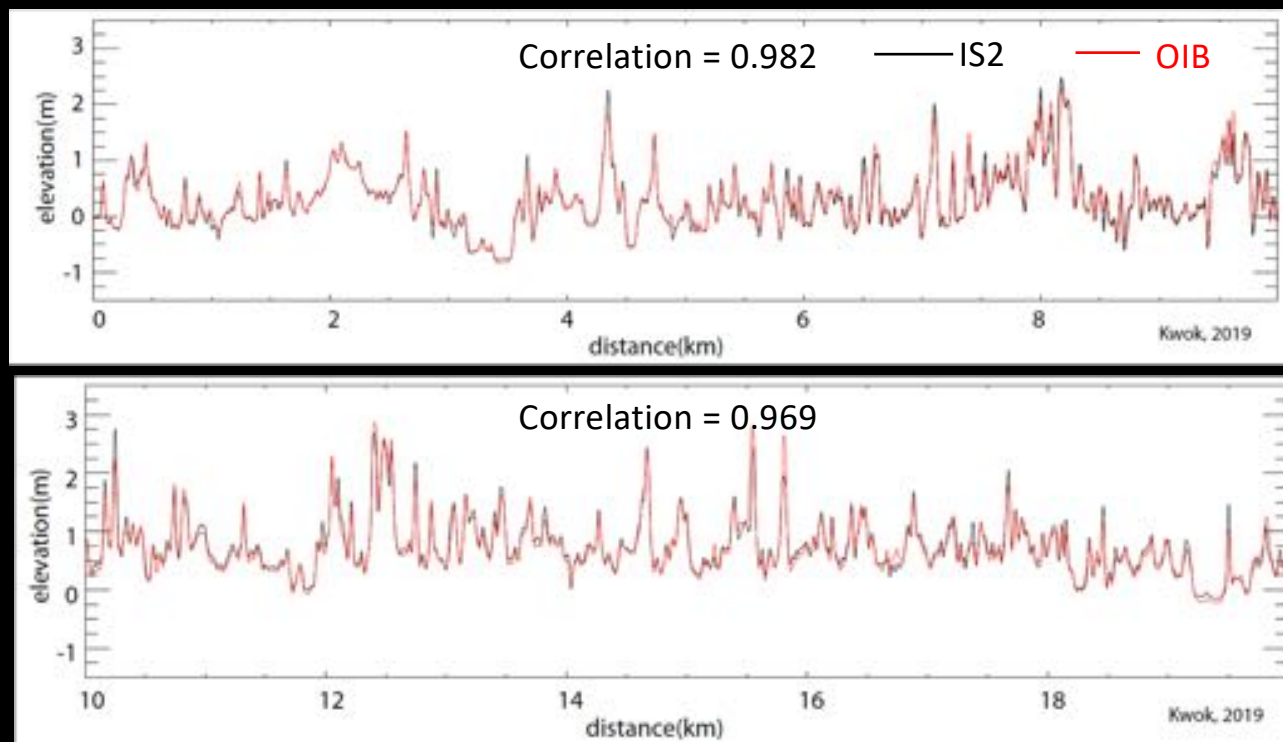
Initial data quality: < 10 cm vertical, < 10m horizontal

Data Release 002 coming in October





Ron Kwok, JPL



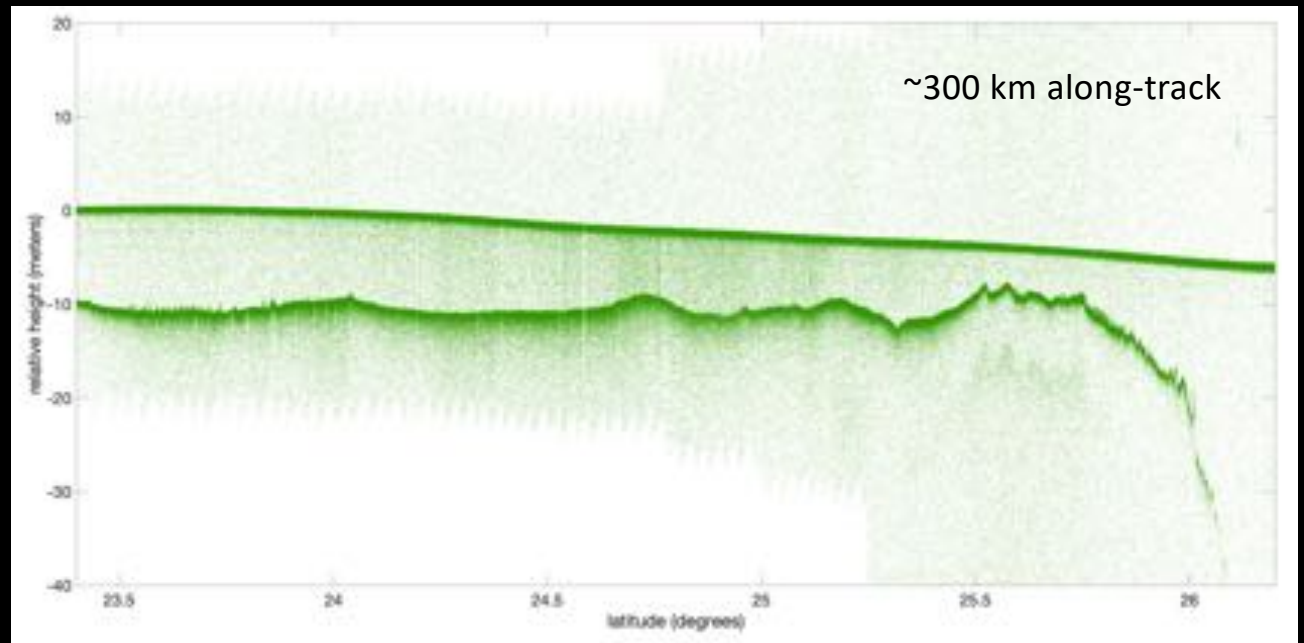
April 8, 2019 Operation IceBridge underflights of ICESat-2 tracks (Arctic Ocean sea ice)

ICESat-2 Measures Bathymetry



Depending on water clarity, ICESat-2 measures both the water surface elevation, and bathymetry (up to ~30m).

We do not have a bathymetry product currently – lots of interest from science community, USCG, USGS, NGA, etc.



ATL03, Grand Bahama Bank, 26 October 2018